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TEMPERATURE CONTROLLER

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This invention relates to temperature control systems and more particularly to an apparatus for accurately controlling temperature within closely defined limits.

It has long been known in the prior art that a temperature control unit which is of the on-off type has a zone which extends over both sides of the actual "control point" within which there is no control or regulation of temperature. This zone is commonly referred to as the "dead zone." This zone results form the fact that in the unit the temperature of which is being controlled, the heating element is remote from the temperature sensing element, such as a thermocouple, with a mass intervening and, therefore, the temperature of the sensing element always lags behind the heating element temperature. This being the case the temperature control unit will, after an "on" cycle, remove power from the heating elements within the unit only after the temperature of the elements has risen beyond the "control point," resulting in overshoot.

The same occurs after an "off" cycle. The temperature will continue to drop below the "control point" since the sensing element of the controller lags behind and senses the control point temperature only after the temperature of the heating elements has fallen below the control point.

This dead zone has created a problem in the temperature control art particularly in those areas wherein it becomes desirable to control the temperature of a given unit such as a furnace or the like within closely specified limits.

One method of substantially eliminating this dead zone has long been known to the art and is very commonly referred to as the Gouy principle and the devices for practicing this principle are referred to as Gouy modullators. This principle is simply that the voltage which is generated by the thermocouple unit which is sampling the temperature to be controlled has superimposed thereon an oscilliating voltage in order to cause power to be applied or removed from the heating elements within the unit to be controlled sooner than it normally would be, and at a frequency greater than the normal temperature cycling of the unit itself. This results in a method of operation often called "proportional control" which means that the ration of "on" cycle duration to "off" cycle duration is proportional to the temperature deviation from the control point. In such a manner the average temperature of the unit remains substantially constant. A discussion of one type of Gouy modulator may be found by reference to Temperature, Its Measurement and Control in Science and Industry, published by Reinhold Publishing Corp., 1941, pages 613–616. It is therein shown that the thermocouple voltage is varied by varying the resistance of a 1 ohm resistance wire in series with the thermocouple. This variation is accomplished by shorting more or less of the resistance wire by passing a column of mercury thereover. This, in turn, is accomplished by containing the wire and mercury with a glass tube and oscillating the glass tube at a rate which is faster than the normal temperature cycling of the controller-furnace combination.

Other types of devices have also been employed to carry out the Guoy principle of temperature control. Examples of such devices are rotating potentiometers or automatically movable slide wires which are contained in series with the thermocouple circuit. Such devices are usually used in laboratories in connection with controllers which utilize mirror galvanometers and photocells to obtain the on-off control.

While these prior art circuits and devices have worked quite well, each of them has several inherent limitations and some disadvantages when applied to certain temperature control functions. In almost every instance wherein a mechanical device is utilized in order to obtain the voltage fluctuation desired, a rather complex and sometimes cumbersome mechanical machinery is involved. Such machinery becomes quite expensive and because it is complex, the maintenance problems with respect thereto become quite large. In addition, as above pointed out, many of these systems require high sensitivity meters or galvanometers in order to be effective. An additional problem is that when resistors or potentiometers or the like are placed in series with the thermocouple circuit and thereafter varied in order to vary the voltage in the thermocouple circuit, spurious voltages appear in the circuit which in turn cause erratic operation of the control apparatus itself. These voltages may be generated by the contact on the slide wire or rotating potentiometer moving over the potentiometer itself, or these voltages may be generated by the contacts between the resistance elements and the thermocouple circuit. This would result since the materials out of which the thermocouple circuit and the resistors themselves are constructed would be different.

Accordingly, it is an object of the present invention to provide a temperature control apparatus that is inexpensive to construct and is simple in operation.

It is another object of the present invention to provide an apparatus for controlling temperature which is very accurate.

It is another object of this invention to provide an apparatus which utilizes the proportional control principle.

It is yet another object of the present invention to provide an apparatus for controlling temperature which requires virtually no maintenance and which, in turn, has a long useful lifetime.

It is still another object of the present invention to provide an apparatus for controlling temperature in which quite inexpensive metering units may be utilized, while at the same time maintaining accurate control of temperature.

It is a still further object of the present invention to provide a temperature control apparatus that is constructed in such a manner as to keep foreign materials from the thermocouple circuit, therefore, eliminating introduction of spurious voltages into the thermocouple circuit.

It is a still further object of the present invention to provide a temperature control unit that is easily removed from operation without disturbing the continuity of the thermocouple circuit itself.

Temperature control apparatus, in accordance with the present invention, includes for utilization in a thermocouple control system means for generating a recurring magnetic field. At least one leg of the thermocouple circuit is coupled by means of suitable instrumentalities to said magnetic field in order to induce and superimpose a recurring voltage upon the voltage generated by the thermocouple unit.

Other and more specific objects of the present invention will become apparent from a consideration of the following description taken in conjunction with the accompanying drawing which is presented by way of example only and is not intended as a limitation upon the scope of this invention, in which:

FIG. 1 is a schematic diagram partly in block form of a system employing the apparatus of the present invention.